PATENT SPECIFICATION

846,583

Inventor: FREDERICK WILLIAM WALTON MORLEY

Date of filing Complete Specification: July 22, 1958

Application Date: August 2, 1957. No. 24648/57

Complete Specification Published: August 31, 1960

Index at Acceptance:—Class 110(3), B2B2.

International Classification:—F01d.

COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements in or relating to Rotor Blading of Fluid Machines, for example, of Compressors and Turbines of Gas Turbine Engines

We, ROLLS-ROYCE LIMITED, a British Company, of Nightingale Road, Derby, in the County of Derby, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention comprises improvements in or relating to rotor blading of fluid machines, for example of turbines or compressors such as are employed in gas turbine engines.

According to the present invention, a rotor blade for a fluid machine comprises a main portion which in use projects into the working fluid stream of the machine, and a shroud along the leading edge of the main portion, the main portion having an internal lengthwise passage to which a fluid is fed in use of the blade, and having in each of its surfaces which extend from the leading edge to the trailing edge, a multiplicity of lengthwise-spaced grooves, each groove extending generally chordwise from the leading edge part way towards the trailing edge and being separated from each adjacent groove by a land of metal, and the main portion further having outlets from the internal passage opening at the leading edge of the main portion, and the shroud comprising a nose portion extending around the leading edge of the main portion in spaced relation to the passage outlets and side portions extending from the nose portion part way only along the said grooves, the side portions being in contact with and rigidly secured to the lands.

In use of the rotor blade, the fluid fed to the passage flows through the outlets into the space between the outlets and the nose portion of the shroud, then from this space through the grooves and from the groove in the form of a film over the portions of the surfaces between grooves and the trailing edge of the main portion.

The rotor blade of this invention has an important use in turbine rotors of gas turbine engines, in which a coolant for the blade is fed to the passage therein.

According to a preferred feature of this invention, some of the lands between the grooves are continuous around the leading edge to provide locating projections for the nose portion of the shroud, and the passage outlets open at the leading edge in flats extending lengthwise between the projections.

According to another preferred feature of the invention, the side portions of the shroud are slightly corrugated so as to fit snugly on the lands and to project slightly into the grooves.

This invention also comprises a fluid machine, for example an axial-flow turbine having a rotor comprising a ring of blades as above set forth, the machine being adapted to permit a flow of fluid to the passages in the blades, for instance a flow of a coolant in the case of turbine rotor.

One construction of blade according to this invention will now be described with reference to the drawings accompanying the Provisional Specification in which:—

Figure 1 is a side elevation of the blade

Figure 2 is a section on the line 2-2 of Figure 1;

Figure 3 is a section on the line 3-3 of Figure 1, not showing the leading edge shroud, and

Figure 4 is a section on the line 4-4 of Figure 1 drawn to a larger scale.

The blade shown is a rotor blade for an axial-flow gas turbine.

The blade comprises a main portion 10 on which the working fluid operates, a tip shroud

11 at its outer end, and a mounting root 12 at its opposite end. The mounting root 12 (Figure 1) comprises a fir-tree portion 12*a* which engages a correspondingly shouldered slot in a rotor disc of the turbine (not shown), a platform 12*b* adjacent the main portion 10, the platforms 12*b* of a ring of such blades together forming an annular portion of the working fluid passage of the turbine, and a stem 12*c* which is circumferentially narrower than the outer end of the fir-tree portion 12*a* and the platform 12*b* so that the mounting roots 12 of adjacent blades define a tunnel to convey coolant air to a recess 12*d* in the circumferentially facing surface of the stem. A port 13 opens into the recess 12*d* and connects the recess with an internal passage 14 extending lengthwise through the main portion 10 adjacent the leading edge. Alternatively, as shown in chain lines in Figure 1, a port 15 may connect the recess 12*d* to a passage 16 extending lengthwise through the blade adjacent its trailing edge and connected by a cross passage 17 to the outer end of passage 14 which in this case may be blanked off at its inner end.

The leading edge of the blade is machined away to form a series of lengthwise-extending flats 18 (Figure 3) separated by projections 19 and a series of length-wise-spaced passage outlets 20 extend from the flats to the passage 14.

The concave and convex surfaces 10*a*, 10*b* of the main portion 10 of the blade are formed each with a series of lengthwise-spaced grooves 21. The grooves 21 extend in the surfaces 10*a*, 10*b* from the flats 18, in a generally chordwise direction part way towards the trailing edge of the blade and the grooves 21 are separated by lands 22 and the projections 19 are in effect continuations around the leading edge of some of the lands 22. The outlets 20 are level with those lands 22 not associated with projections 19.

The blade also comprises a sheet metal shroud 23 extending along the grooved portion of the leading edge of the main portion 10 of the blade. The shroud comprises a nose portion 23*a* which is curved to give the blade a good aerodynamic form and to seat on the projections 19, and a pair of side portions 23*b* overlying the grooves 21 but extending in a direction towards the trailing edge only part way along the length of the grooves. The shroud 23 is in contact with the lands 22 and is secured in position by being brazed to the lands 22 (Figure 4). Also the side portions 23*b* are slightly corrugated (Figure 4) so as to fit snugly on tthe lands 22 and to project slightly into the grooves 21.

In use coolant air flows into the passage 14 from the root end of the blade and then flows through the outlets 20 into the spaces between the nose portion 23*a* of the leading edge shroud and the flats 18. The air then flows rearwardly in the grooves 21 towards the trailing edge of the blade and on leaving the grooves flows as a thin film over the portions of the blade surfaces 10*a*, 10*b*, extending between the grooves 21 and the trailing edge of the blade. In this way effective cooling of the blade is obtained.

If desired, additional passage outlets corresponding to outlets 20, can be provided between the trailing edge of the blade and passage 16 to provide film cooling of the trailing edge of the blade.

WHAT WE CLAIM IS:—

1. A rotor blade for a fluid machine comprising a main portion which in use projects into the working fluid stream of the fluid machine, and a shroud along the leading edge of the main portion, the main portion having an internal lengthwise passage to which a fluid is fed in use of the blade, and having in each of its surfaces which extend from the leading edge to the trailing edge, a multiplicity of lengthwise-spaced grooves, each groove extending generally chordwise from the leading edge part way towards the trailing edge and being separated from each adjacent groove by a land of metal, and the main portion further having outlets from the internal passage opening at the leading edge of the main portion, and the shroud comprising a nose portion extending around the leading edge of the main portion in spaced relation to the passage outlets and side portions extending from the nose portion part way only along the said grooves, the side portions being in contact with and rigidly secured to the lands.

2. A rotor blade as claimed in claim 1 wherein some of the lands between the grooves are continuous around the leading edge to provide locating projections for the nose portion of the shroud.

3. A rotor blade as claimed in claim 2 wherein the passage outlets open at the leading edge in flats extending lengthwise between the projections.

4. A rotor blade as claimed in claim 2 or claim 3 wherein the passage outlets open at the leading edge level with lands which are not continuous around the leading edge.

5. A rotor blade as claimed in any of claims 1 to 4, having a root mounting at one end wherein the internal lengthwise passage extends in the main portion of the blade adjacent the leading edge, the passage being connected with an inlet port in a surface of the root mounting.

6. A rotor blade as claimed in claim 5, comprising a further lengthwise passage extending in the main portion adjacent the trailing edge and connected with the first said passage at its end remote from the root mounting, the further passage having an inlet port in a surface of the root mounting and the first said passage at its end adjacent

the root mounting either being open to a port in a surface of the root mounting or being blanked off.

7. A rotor blade as claimed in claim 6, wherein outlets are provided from the further passage to the trailing edge of the main portion in a manner to give film cooling of the trailing edge.

8. A rotor blade as claimed in any of claims 1 to 7 wherein the side portions of the shroud are slightly corrugated so as to fit snugly on the lands and to project slightly into the grooves.

9. A rotor blade for a fluid machine substantially as hereinbefore described with reference to and as illustrated in the drawings accompanying the Provisional Specification.

10. A fluid machine having a rotor comprising a ring of blades as claimed in any preceding claim, the machine being adapted to permit a flow of a fluid to passages in the blades.

11. A fluid machine as claimed in claim 10 wherein the rotor is a turbine rotor and the fluid flowing in the passages is a coolant.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden,
London, E.C.1.
Chartered Patent Agents.

PROVISIONAL SPECIFICATION

Improvements in or relating to Rotor Blading of Fluid Machines, for example, of Compressors and Turbines of Gas Turbine Engines

We, ROLLS-ROYCE LIMITED, a British Company, of Nightingale Road, Derby, in the County of Derby, do hereby declare this invention to be described in the following statement:—

This invention comprises improvements in or relating to rotor blading of fluid machines, for example of turbines or compressors such as are employed in gas turbine engines.

According to the present invention, a rotor blade for a fluid machine comprises a main portion which in use projects into the working fluid stream of the machine, and a shroud along the leading edge of the main portion, the main portion having an internal lengthwise passage to which a fluid is fed in use of the blade, and having in each of its surfaces which extend from the leading edge to the trailing edge, a multiplicity of lengthwise-spaced grooves, each groove extending generally chordwise from the leading edge part way towards the trailing edge and being separated from each adjacent groove by a land of metal, and the main portion further having outlets from the passage opening at leading edge of the main portion, and the shroud comprising a nose portion extending around the leading edge of the main portion in spaced relation to the outlets and side portions extending from the nose portion part way only along the grooves, the side portions being in contact with and rigidly secured to the lands.

In use of the rotor blade, the fluid fed to the passage flows through the outlets into the space between the outlets and the nose portion of the shroud, then from this space through the grooves and from the grooves in the form of a film over the portions of the surfaces between grooves and the trailing edge of the main portion.

The rotor blade of this invention has an important use in turbine rotors of gas turbine engines, in which a coolant for the blade is fed to the passage therein.

According to a preferred feature of this invention, some of the lands between the grooves are continuous around the leading edge to provide locating projections for the nose portion of the shroud, and the outlets open at the leading edge in flats extending lengthwise between the projections.

According to another preferred feature of the invention, the side portions of the shroud are slightly corrugated so as to fit snugly on the lands and to project slightly into the grooves.

This invention also comprises a fluid machine, for example an axial-flow turbine having a rotor comprising a ring of blades as above set forth, the machine being adapted to permit a flow of a fluid to the passages in the blades, for instance a flow of a coolant in the case of turbine rotor.

One construction of blade according to this invention will now be described with reference to the accompanying drawings in which—

Figure 1 is a side elevation of the blade,

Figures 2 and 3 are sections on the lines 2-2 and 3-3 respectively of Figure 1, and

Figure 4 is a section on the line 4-4 of Figure 1 drawn to a larger scale.

The blade shown is a rotor blade for an axial-flow gas turbine.

The blade comprises a main portion 10 on which the working fluid operates, a tip shroud 11 at its outer end, and a mounting root 12 at its opposite end. The mounting root 12 (Figure 1) comprises a fir-tree portion 12*a* which engages a correspondingly shouldered slot in a rotor disc of the turbine, a platform 12*b* adjacent the main portion 10, the platforms 12*b* of a ring of such blades together form an annular portion of the working fluid passage of the turbine, and a stem 12*c* which is circumferentially narrower than the outer end of the fir-tree portion and the platform so that the mounting roots 12 of adjacent blades define a tunnel to convey coolant air to a recess 12*d* in the circumferentially facing surface of the

stem. A port 13 opens into the recess 12*d* and connects the recess with a passage 14 extending lengthwise through the main portion 10 adjacent the leading edge. Alternatively a port 15 may connect the recess 12*d* to a passage 16 extending lengthwise through the blade adjacent its trailing edge and connected by a cross passage 17 to the outer end of passage 14 which in this case may be blanked off at its inner end.

The leading edge of the blade is machined away to form a series of flats 18 (Figures 1, 2 and 3) separated by projections 19 and a series of lengthwise spaced outlet holes 20 extend from the flats to the passage 14.

The concave and convex surfaces 10*a*, 10*b* of the main portion 10 of the blade are formed each with a series of grooves 21. The grooves 21 extend in the surfaces 10*a*, 10*b* from the flats 18, in a generally chordwise direction part way towards the trailing edge of the blade and the grooves 21 are separated by lands 22 and the projections 19 are in effect continuations around the leading edge of some of the lands 22. The holes 20 are level with those lands not associated with projections 19.

The blade also comprises a sheet metal shroud 23 extending along the grooved portion of the leading edge of the main portion of the blade. The shroud comprises a nose portion 23*a* which is curved to give the blade a good aerodynamic form and to seat on the projections 19, and a pair of side portions 23*b* overlying the grooves 21 but extending in a direction towards the trailing edge only part way along the length of the grooves. The shroud 23 is in contact with the lands 22 and is secured in position by being brazed to the lands 22 (Figure 4). Also the side portions 23*b* are slightly corrugated (Figure 4) so as to fit snugly on the lands 22 and to project slightly into the grooves 21.

In use coolant air flows into the passage 14 from the root end of the blade and then flows through the outlets 20 into the spaces between the nose portion 23*a* of the leading edge shroud and the flats 18. The air then flows rearwardly in the grooves 22 towards the trailing edge of the blade and on leaving the grooves flows as a thin film over the portion of the blade surfaces 10*a*, 10*b* extending between the grooves 21 and the trailing edge of the blade. In this way effective cooling of the blade is obtained.

If desired additional holes, corresponding to holes 20 can be provided between the trailing edge of the blade and passage 16 to provide film cooling of the trailing edge of the blade.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden,
London, E.C.1.
Chartered Patent Agents.

Berwick-upon-Tweed: Printed for Her Majesty's Stationery Office, by The Tweeddale Press Ltd.—1960.
Published at The Patent Office, 25 Southampton Buildings, London, W.C.2., from which copies may be obtained.

Fig.1.

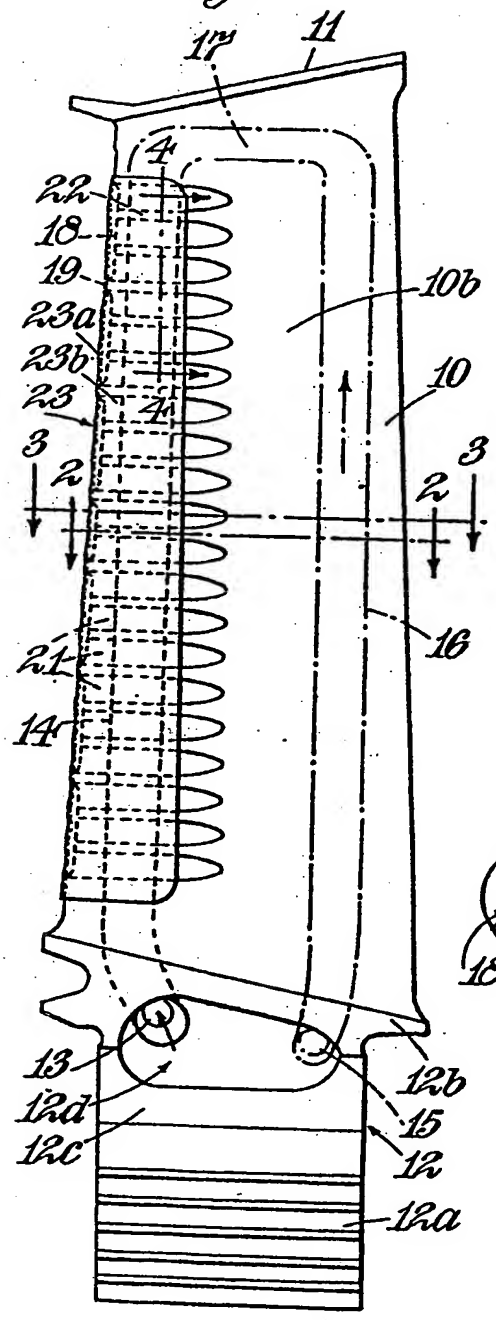
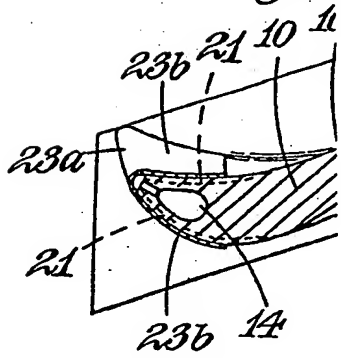
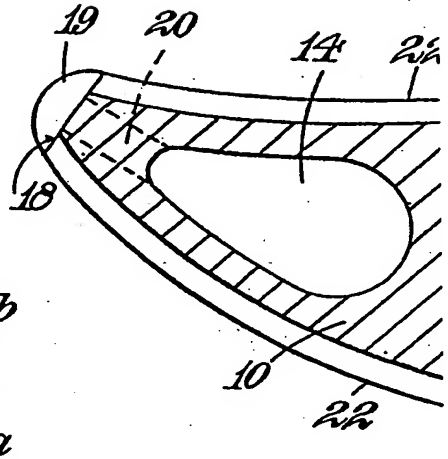

17
11
4
22
18
19
23a
23b
23
4
3
2
3
2
10b
10
16
21
14
13
12d
12c
12b
15
12
12a

Fig.4


23b
21
10
23a
21
23b
14

F


19
20
14
18
10
22

846,583 PROVISIONAL SPECIFICATION
1 SHEET

Fig.2.

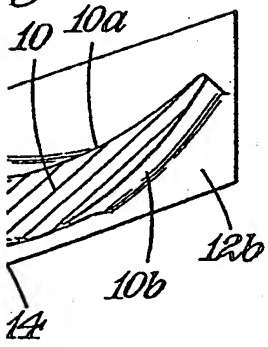


Fig.4.

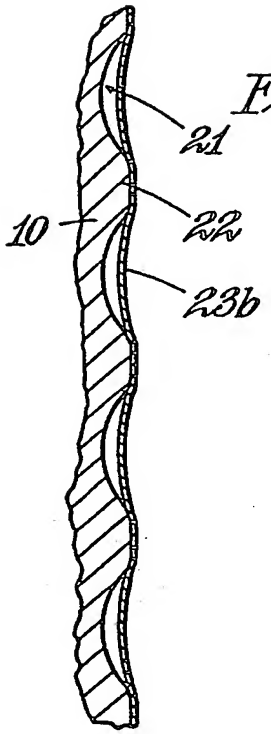


Fig.3.

846,583 PROVISIONAL. SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

Fig.1.

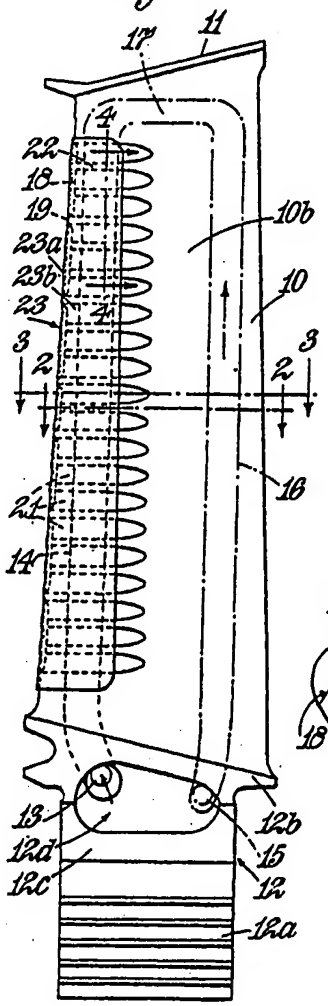


Fig.2.

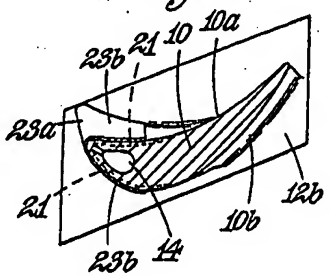


Fig.4.

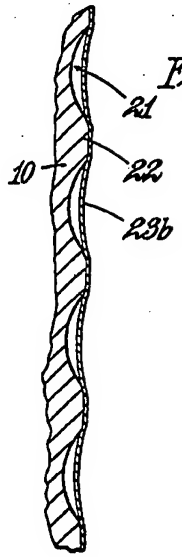


Fig.3.